11 Climate Change Economics

11 Climate Change Economics

Perhaps the most fundamental social problem in solving the climate change problem is that the ***atmosphere mixes CO_2 and other greenhouse gases globally but the costs of mitigating and adapting to the impacts of climate change are borne locally***. Even worse, the ***consequences of today's CO_2 emissions will persist for many centuries or even millennia, so most of the harm will be done to people who haven't yet been born***.

Economists see this disconnect between local near-term costs and global long-term consequences as providing ***powerful perverse incentives for "free riding"*** on others' efforts. The global long-term nature of the climate problem guarantees that nearly all the benefits of local near-term mitigation will accrue to other people far away in space and time. This disconnect between mitigation costs to "us" and the benefits of avoided damage to "them" saps political and economic will needed to motivate heroic efforts to eliminate CO_2 emissions in the here and now.

Much of the economic discourse on climate change is focused on ways to ***engineer near-term incentives to eliminate CO_2 emissions and thereby overcome the free-rider phenomenon*** in which everyone depends on the effort of others. Economic incentives can reward good behavior (with subsidies or outright grants) or penalize bad behavior (with taxes or fines). Either way, economists seek ways to shift the costs of future climate damages from people far away onto people here and now so that they will rationally spend money to mitigate those costs.

As a group, economists tend to be very skeptical of the idea that people will "do the right thing" in an altruistic way to avoid harming others. They assume that large groups of people behave according to a rational comparison of costs and benefits "at the margin." This means that decisions are made locally in space and time. This has led to a very ***powerful consensus among academic economists that the best way to avoid ("mitigate") long-term global climate damages is by "putting a price on carbon emissions."***

The idea is to estimate the long-term economic damages that will arise from failing to invest in clean energy and energy efficiency in the near-term and add those costs to the price of fossil fuels. Higher prices for fuels reduce the demand for them and (since people still need energy), it increases the demand for alternatives and for saving energy. Those ***integrated long-term damages (and the corresponding near-term "carbon price") are called the "Social Cost of Carbon"*** and there's a big research effort to quantify it.

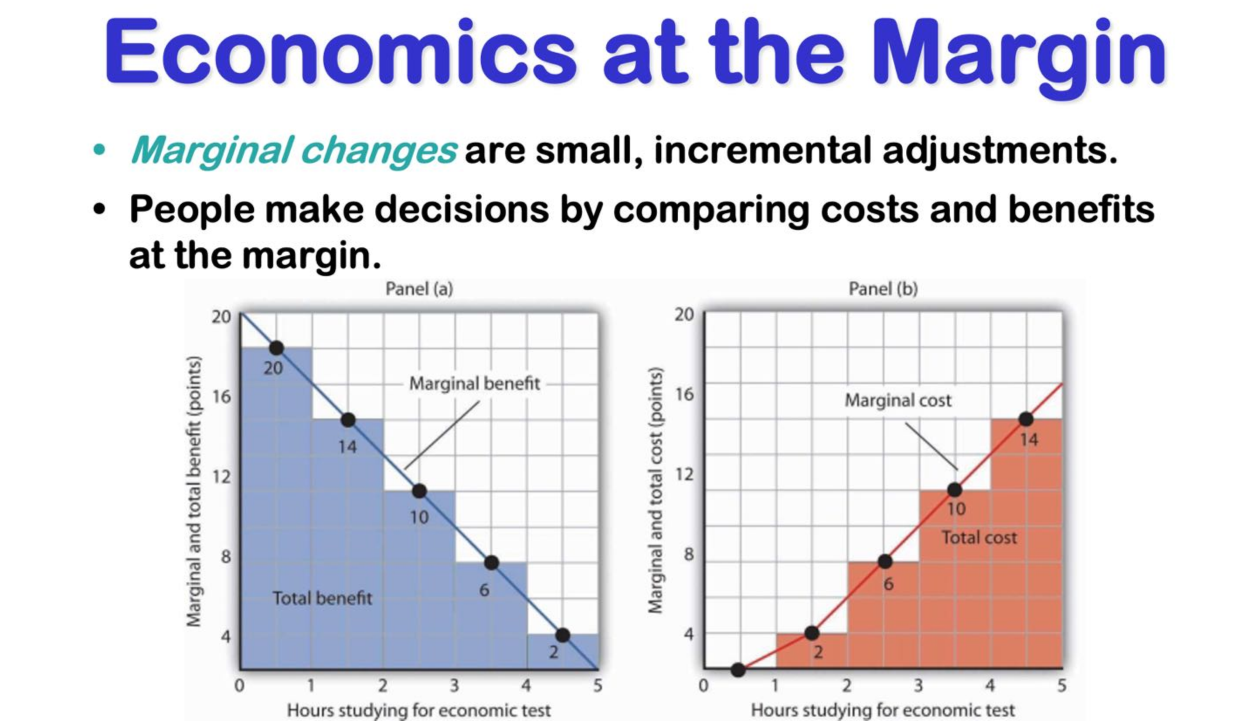
This is harder than it sounds! As we've seen, the effects of CO_2 emissions on the physical climate are uncertain. The impacts of those changes on natural and social systems are harder to predict. And the costs of those impacts are more uncertain still. How much will the loss of coastal real estate to more frequent floods cost? How about the cost of absorbing hundreds of millions of refugees from coastal cities? What about the geopolitical disruptions and wars that might plunge billions of people into crisis?

One of the most difficult aspects of pricing carbon emissions is the "time value of money." ***Costs in the future must be "translated" to present dollars using some kind of formula that "discounts" future money***. This turns out to be very contentious, as we will see!

11.1 Efficient Markets

11.1.1 Balancing Marginal Costs and Benefits

Economists define “markets” as collections of rational people who constantly make decisions that balance costs and benefits “at the margin.” *Marginal costs and benefits are small incremental adjustments that reflect conditions that in the here and now*, not wisely integrated over the future by some kind of far-seeing perspective.



As an example, consider your costs and benefits involved in studying for the recent exam in this class. The “benefit” of studying is the opportunity to get more points on the exam, and your “cost” is the sacrifice of hours of your precious time studying that could otherwise be spent having more fun.

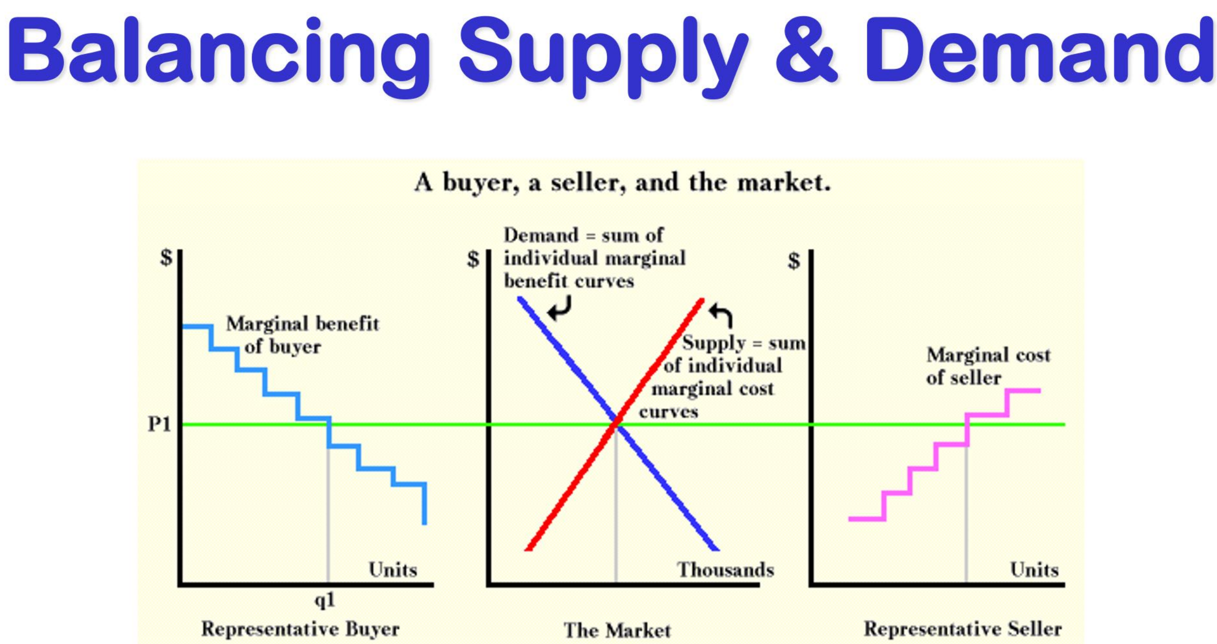
Like so many things in life, the *marginal costs* of studying get steeper with effort. Your first hour of studying might displace a visit with a friend or a favorite TV show. Your third hour studying might displace something more important like another class. By the fifth hour, your studying for this exam might displace important sleep. *Marginal costs escalate* as you sacrifice more and more opportunity for other goods for this one.

But the *marginal benefits* of studying one more hour for the exam actually decrease the more effort you spend. You might get 20 extra points on the exam by studying one hour (as compared to no studying at all). But putting in a second hour of effort might only earn you 10 more points than studying that first hour. By the time that exhausted fifth hour of studying rolls around you likely have wrung all the points out of this damned exam that you're ever going to get. This common phenomenon is known as "*diminishing returns*."

Most people faced with escalating marginal costs and diminishing marginal benefits will call it a day at the point when they perceive that the next unit of effort costs more than it's worth. This is what economists call balancing marginal costs and benefits.

11.1.2 Supply and Demand

In a market for some economic good, there may be thousands or even millions of buyers and sellers. Economists assume that each market participant (buyer and seller) is a rational actor responding to her own marginal costs and benefits, and that the *integrated behavior of the entire market balances the aggregated marginal costs (called supply) against aggregated marginal benefits (called demand).*



Consider a graph showing the price of a particular good on the y-axis against the amount of that good bought or sold on the x-axis. The market mechanism (millions of rational buyers and sellers each of whom balances their marginal costs against marginal benefits) is characterized by a rising supply curve and a falling demand curve on this graph.

Supply rises with price. The higher the price, the more of the good that sellers will produce because higher prices allow them to profit even though it costs them a lot to produce more and yet more of that good. Low prices cut into sellers' profits so they are incentivized to cut production.

Demand falls with price. The more expensive a good becomes, the less people want to buy because the benefit of acquiring another unit is less than their cost. Conversely low prices stimulate demand.

The *market mechanism* sets both the price of goods (on the y-axis) and the quantity bought and sold (on the x-axis) at the point where *supply and demand are balanced*. Rational sellers produce just enough of a good and rational buyers acquire just enough to balance supply and demand at *price P1* and *quantity Q1*.

11.1.3 Efficient Markets Produce the "Greatest Good"

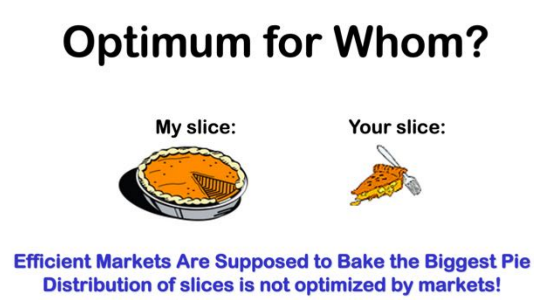
Economists often assume that when markets are left alone and information about goods and services is available to all buyers and sellers, then they *efficiently produce the best possible outcome.* There are both technical and ethical (value-laden) aspects to this assumption.

Economic incentives can be provided by policy that can influence prices and quantities by artificially adjusting supply and demand. For example, subsidies can inflate demand by providing money to buyers to make prices appear lower. As the equilibrium price falls, supply will increase to meet rising demand. Conversely, policy can reduce demand by adding a penalty or tax to the price of goods. The downward shift in demand reduces equilibrium supply and the quantity of the good sold decreases.

Of course, the money for subsidies or penalties has to come from someplace and economists are often skeptical that this wealth transfer is an "efficient" or "optimal" use of that money. Even if subsidies or penalties produce the desired changes in prices and quantities produced, we must ask whether the money diverted to changing the market outcome might have been better spent elsewhere. This is known as *opportunity cost*, meaning that spending money to obtain the desired outcome led to a lost opportunity to do something else.

Defining a best outcome of market economics requires making value judgements. Traditionally, economists use a measure of "goodness" called aggregate utility. The idea here is to add up all the costs and benefits of all market participants. Subtracting the aggregate costs from the aggregate benefits gives the net utility or "goodness." We say that efficient markets produce "the greatest good for the greatest number."

Importantly, *aggregate utility measures the goodness of an outcome only across the entire market and makes no claim about the relative goodness or badness of outcomes for any individual or subgroup*. Markets optimize the average or total utility but are not interested in the relative shares of various participants. These unoptimized shares are known as "*distributional effects*," and tend to be especially important to politics and therefore policy!



11.2 Market Externalities

One of the worst problems with markets is that in the real world some costs and benefits are invisible to buyers and sellers. These are called *market externalities*.

External costs and benefits involve the exchange of real money but are structurally excluded from markets and therefore lead buyers and sellers to set prices and quantities of good and services inefficiently. In the language of economics *these bad outcomes are called market failures because they fail to produce the most aggregate utility* (they make the pie smaller than it could have been).

11.2.1 Pollution and Power Markets

The economic harm that arises from *pollution is a classic example of a market externality* that leads to market failure.

Consider a coal-fired power plant that provides electricity to a nearby city. The market for electricity is organized to balance demand (by the citizens) and supply (by the power company). This market "automatically" includes costs to the electricity producer such as mining and transporting coal, building and maintaining transmission infrastructure, and interest on debt through utility bonds. It also includes costs to electricity consumers in the form of their utility bills. Benefits to consumers are lighting, heating, and entertainment. Benefits to producers are the profits they earn on their sales to the consumers. Prices and quantities of electricity are efficiently set by the market.

But what about the clouds of smoke and soot and toxic gases that flow from the power plant over the city immediately downwind? These impose real costs on the citizens. Street trees die and must be replaced. Soot collects on windows and walls and must be regularly cleaned off. People get sick, pay exorbitant hospital bills, and miss work and time with their families. Worst of all, large numbers of them may die young, which is an overwhelming opportunity cost in their lost years of productive and enjoyable life!

This is a classic example of market failure, because the market has led to an outcome with a small pie. The very real costs that are born by electricity consumers but not reflected in the price of electricity are called external costs to the market for electrical power. If these *externalities* were *internalized* – that is, if they were added to the retail price of electricity – then less electricity would be purchased. Less coal would be burned. Fewer people would be sick and die young. The market failure would be mitigated.

Environmental economists prescribe a policy of pollution taxes to remedy this market failure caused by market externalities. The government of the city, alarmed by the high costs of illness and early death, impose punitive taxes on the electricity sold by the upwind power company. Demand for electricity falls. The power company makes less profit. They may rationally invest in scrubbers for their smokestacks or even switch to wind and solar power to avoid the tax penalty. The overall goodness of the outcome (the size of the pie) increases.

The analogy between pollution externalities and the costs of climate change are pretty obvious. Just as pollution taxes can remedy the market failure that led to dying young citizens, pricing carbon may be expected to reduce demand for fossil fuels, incentivize the switch to renewable energy, and cure the market failure of climate change.

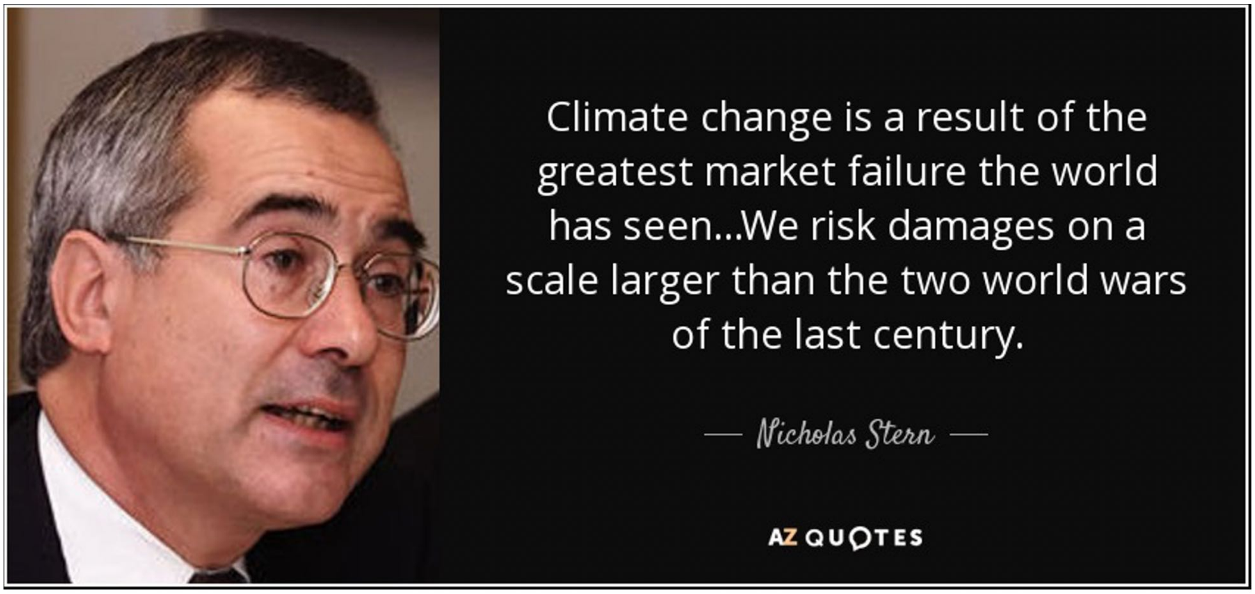
11.2.2 “The Greatest Market Failure the World Has Seen”

The trouble with climate change is that the market externalities are extremely removed from market participants in both space and time.

Consumers of energy want as much as they can afford in the here and now and sellers of energy want to make as much money as they can. The very real costs of climate change in lost land and productivity, in human lives and species loss and environmental devastation are diluted across the whole world and all its faraway billions of people. Worst of all, the costs escalate over decades and centuries so that they fall on dozens of generations of people yet to be born, ultimately aggregating into essentially infinite damages to hundreds of billions of people over many millennia.

It's hard to even imagine the economic devastation of climate change on all those hundreds of billions of future people, let alone add them to the price of a gallon of gasoline or a kW-hr of electricity. The damages are just too far away and the benefits from that gallon of gas are just too immediate and juicy to forgo.

Describing this terrible distance between the costs and benefits of fossil fuels, Sir Nicholas Stern at the London School of Economics calls climate change "the greatest market failure in history."



The *impacts* are potentially huge: left unchecked, CO_2 emissions may lead to economic and political collapse and even a mass extinction comparable to the five great mass extinctions over all of geologic time. The *distances* between market actors and the effects of their actions are unfathomably immense: they are both *international* in the sense that almost everyone affected is a citizen of another country than the actor and *intergenerational* in the sense that most of the people harmed by today's emissions haven't even been born yet!

The decisions that balance supply and demand for fossil fuels and ultimately CO_2 emissions are taken every day by billions of people all over the planet every time they switch on a light, buy a product, or take a drive. None of those small decisions has a detectable impact on the climate and yet taken together the global impact of the collective CO_2 emissions has the potential to destroy the world. This *situation is deeply disempowering and dispiriting: none of us acting alone can meaningfully slow CO_2 emissions and avoid catastrophe. Somehow, we must all act together to avert a tragic outcome that eliminates that yummy pie for everyone*.

To make matters worse, there is literally *no global authority to alleviate the market externality caused by CO_2 emissions*. Unlike the power plant example above, there is no analogy to the city government that can legally impose a tax on the fuel that causes the damages. Because CO_2 is a globally well-mixed gas nearly all the economic damages of burning fossil fuels fall outside the country that burned the carbon. National governments can impose a price on carbon to incentivize efficiency or energy innovation, but they are likely to internalize only the small part of the damages that fall within their borders. This problem of local costs and globally diluted benefits applies even more strongly to regions, states, and local governments.

The market failure represented by climate change and CO_2 emissions is very difficult to solve from a traditional economic point of view. Social scientists call it a "*wicked problem*."

11.3 Climate Damages

Attempts to internalize the externalities of CO_2 emissions must begin by accounting for the economic damages of climate change. This is really hard and subject to huge uncertainty!

Traditional economics assumes a *background of exponential growth in income (GDP) and treats changes as small perturbations at the margins* of this steady growth. These assumptions may work for the fairly subtle changes projected in coming decades under scenarios with rapid decarbonization but are poorly suited to the kinds of massive dislocations associated with uncontrolled fossil fuel emissions.

Recall that climate scenarios are calculated starting with socioeconomic storylines that assume future trajectories of population growth, economic development, and trade. Using these scenarios as input, Earth System Models are then used to project detailed conditions every few minutes across the whole world for centuries. The output of these simulations are then used to estimate impacts such as droughts, wildfire, floods, and heat waves.

As we've seen in Modules 8 and 9, these impacts range from fairly moderate changes in temperature and moisture under low-emission scenarios to utterly catastrophic collapses of continental ice sheets with coastal land loss, severe desiccation of soil moisture, and loss of biological productivity under high-emission scenarios.

The economic damages arising from burning fossil fuels are already enormous. One problem is how to distinguish between health costs that are imposed by warming vs those that arise from the air pollution caused by burning fossil fuels. Air pollution from combustion already kills more than 7 million people every year. That's the third leading cause of early death (after heart disease and cancer) and air pollution is probably more deadly than COVID-19. Without strong emission reductions fossil fuels will likely become the leading cause of death in the world over the next few decades. The economic costs of health care for people sickened by air pollution and the lost productivity associated with illness and early death amount to many trillions of dollars every year.

A few economists have considered the possibility of extreme damages that might result from catastrophic climate change. These include cascading financial collapse resulting from the sudden devaluation of "stranded assets" such as coastal real estate or fossil fuel reserves which are commonly used as collateral for loans. The impacts of hundreds of millions of refugees fleeing coastal cities destroyed by flooding or famine caused by widespread crop failure would probably cause massive social unrest and even world war. Contemplating such extreme economic collapse violates the basic assumptions of marginal change for which economic theory was developed.

As economic damages mount, costs compound and spread across regions. It's easy to imagine repeated disasters such as floods and droughts leading to widespread hunger, illness and death, forced migration, and social breakdown. Eventually such damages would affect everyone on Earth. The costs to economic productivity and income would choke off growth and reverse centuries of progress that have improved the human condition since the Industrial Revolution.

Although there have been efforts to estimate economic damages directly from the output of Earth System Models, by far the dominant approach in climate economics has been to use much *simpler calculations called Integrated Assessment Models* (IAMs, further described below in section 11.5).

In most IAMs, climate damages (in dollars of lost income) are assumed to scale with the square of global warming:

$$D_t = a_0 + a_1 T_t + a_2 T_t^2 + f_1\big(SLR(t)\big) + f_2(CO_2\ fertilization)$$

Here D_t is the damage to income at time t and T is the global mean temperature change form preindustrial times in ºC. The parameters a_0, a_1, and a_2 are coefficients of the quadratic relationship between warming and economic damage. The function f_1 adds to the assumed damages depending on sea level rise and the function f_2 subtracts from damages if CO_2 fertilization increases crop production.

The basic assumption with this formulation is that *damages grow slowly at first with a little bit of global warming but then accelerate quadratically*. Double the warming produces four times the damage, and so on. Many economists estimate damages by region or even for every country and assume that damages are proportionately larger for smaller and poorer countries than they are for larger and richer countries.

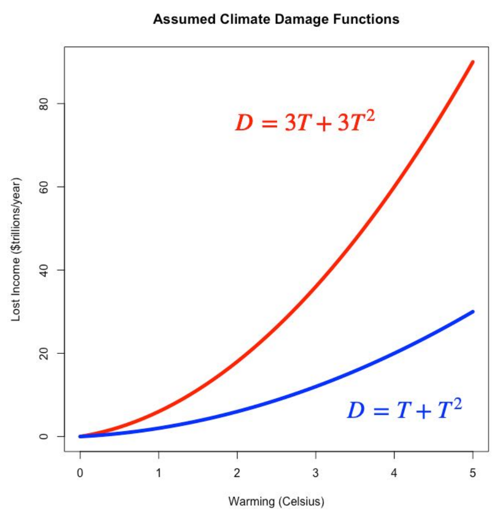


Figure 11-1: Hypothetical climate damage functions using a_1=a_2=3 (red curve) and a_1=a_2=1 (blue curve). Contemporary global income is about \$100 trillion per year

This approach is quite arbitrary and very hard to test against real data. Figure 11-1 shows how sensitive the damage function is to the values of the parameters a_0, a_1, and a_2. The blue curve shows damages escalating to 25% of global income whereas the red curve escalates to nearly complete global economic collapse.

Some economists have tried to estimate these parameters from historical climate or from year-to-year changes in average temperatures. But year-to-year changes are small and temporary, allowing quick recovery. Global warming is large and permanent. Few studies have tried to actually model damages in a deterministic way from projected changes in drought, fires, floods, and heat waves by country and by year.

11.4 Discounting the Future

One of the most contentious aspects of calculating the social cost of carbon is the changing value of money in the future. Indeed, *differences among climate economists in their calculations* *of how future damages are discounted to present dollars is the dominant source of disagreement about their policy recommendations*.

The fundamental idea with discounting is that *people prefer to receive something of value now rather than wait* for it. This is the underlying concept behind charging interest on a loan. The longer the lender is willing to wait for their money, the more the borrower must pay.

11.4.1 Interest Rates and Discount Rates

In accounting, we calculate the future value of a thing of value using compound interest:

$$FV = PV * \exp(r * t)$$

Where FV is the future value, PV is the present value, *r* is the interest rate (percent per year) and *t* is the time in years when we want to calculate the future value.

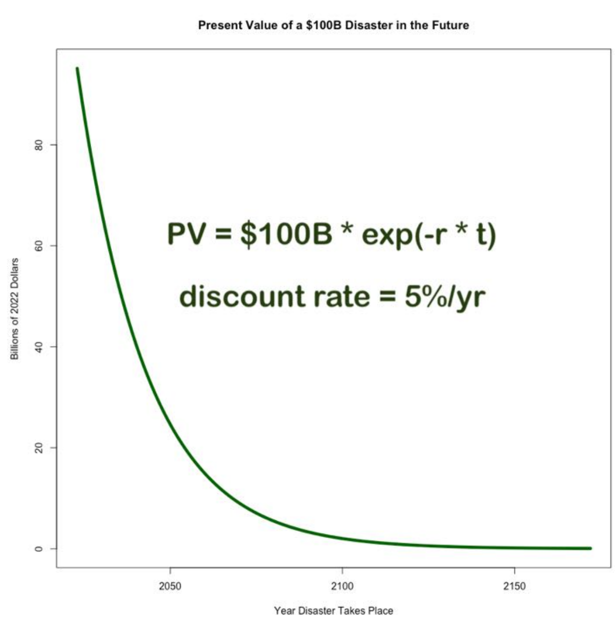
For example, suppose we borrow $100 and promise to pay it back in 5 years at an interest rate of 5%. Five years later the value of the loan will be

$$FV = \$100 * \exp(0.05/\text{year} * 5 \text{ years}) = \$128$$

The present value (PV) = $100. The ***interest rate*** is 5% per year (0.05/yr), and the term of the loan is 5 years.

Discounting is precisely compound interest calculated in reverse. We can say that the present value of $128 five years from now is $100 today, using a 5%/yr discount rate. The formula is just

$$PV = FV * \exp(-r * t)$$



Discounting is incredibly powerful because of its negative exponential behavior. Suppose a climate disaster like a hurricane will occur in 100 years that causes $100 billion in damage to a city (for reference, Superstorm Sandy ravaged the US east coast in 2012, causing about $70 billion in damage). Using a discount rate of 5%/year, the present value of the future hurricane damage is calculated as

$$PV = \$100 \text{ billion} * \exp(-0.05 * 100) = \$0.67 \text{ billion}$$

The city-destroying damage has been devalued by a factor of nearly 200 because it's so far in the future. The present value of $670 million is enough to build a modest 35-story office building, but it's wildly short of the cost to rebuild lower Manhattan.

Now suppose the hurricane destroys the city in 400 years instead of 100 years. How much is that catastrophe worth today?

$$PV = \$100 \text{ billion} * \exp(-0.05 * 400) = \$200$$

Holy cow! According to this formula, wiping out a city in the year 2422 only sets us back about as much a fancy dinner and drinks in that city this weekend!

11.4.2 Cost-Benefit Analysis of Climate Change

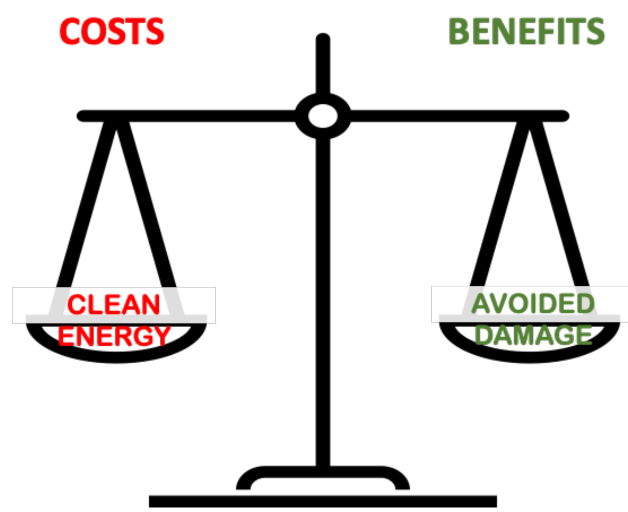
It turns out that *discounting the future is a key feature of climate change economics*.

When economists analyze policy options, one of their favorite tools is to compare costs of a policy against benefits of that policy. Unsurprisingly, this is called "cost-benefit analysis."

Climate policy involves spending money to reduce CO_2 emissions (mitigation) and beefing up infrastructure and other systems to withstand the impacts of climate change (adaptation). Economists frame these policies as having up-front costs (in today's dollars) that we invest to avoid damages in the (discounted) future.

NOTICE THAT THIS IS PRETTY WEIRD!

Remember the horrific consequences of failing to switch out our energy system (the "damages" we considered in the previous section): vast areas of lost coastal land, collapse of the global food supply, financial ruin, hundreds of millions of climate refugees crossing borders, war, disease, and famine. In the context of economic cost-benefit analysis, these unprecedented catastrophes are *NOT CONSIDERED COSTS!*



Rather, *AVOIDING* these terrible consequences are considered *BENEFITS*.

When economists analyze costs and benefits for climate policy, they consider *COSTS* in the *here-and-now* or very near future. These include the costs of building wind and solar power plants, new transmission lines, electric vehicles, and carbon taxes. As you can imagine, these things are pretty pricey!

But the *BENEFITS* (avoiding a global apocalypse decades from now) get *DISCOUNTED* using the exponential formulae we discussed above. Using the example on the previous page, saving New York City from ruin in the distant future is only considered worthwhile if it costs less than dinner and drinks in the here and now.

This ***central feature of climate economics*** is very often misunderstood:

Future catastrophe is aggressively discounted but the costs of avoiding it are not!

11.5 Social Cost of Carbon

Recall from section 11.2 above that climate damages are external to the market for fossil fuels and energy. An important task that climate change economists have set for themselves is to measure these external costs and report them as ***hidden prices of burning fossil fuels***. The resulting carbon price is often called the ***social cost of carbon*** because they are real costs borne by society as a whole but are not reflected in market prices for fuel or electricity or the goods and service produced using energy.

The idea is that policy should somehow internalize these social costs of carbon, for example by enacting a carbon tax or by enacting regulatory caps on emissions and then letting private firms trade carbon permits among themselves to achieve market advantage. If two companies compete in the market for electricity, the firm with better efficiency or cleaner technology would therefore have an advantage through lower carbon prices and therefore beat its competitor.

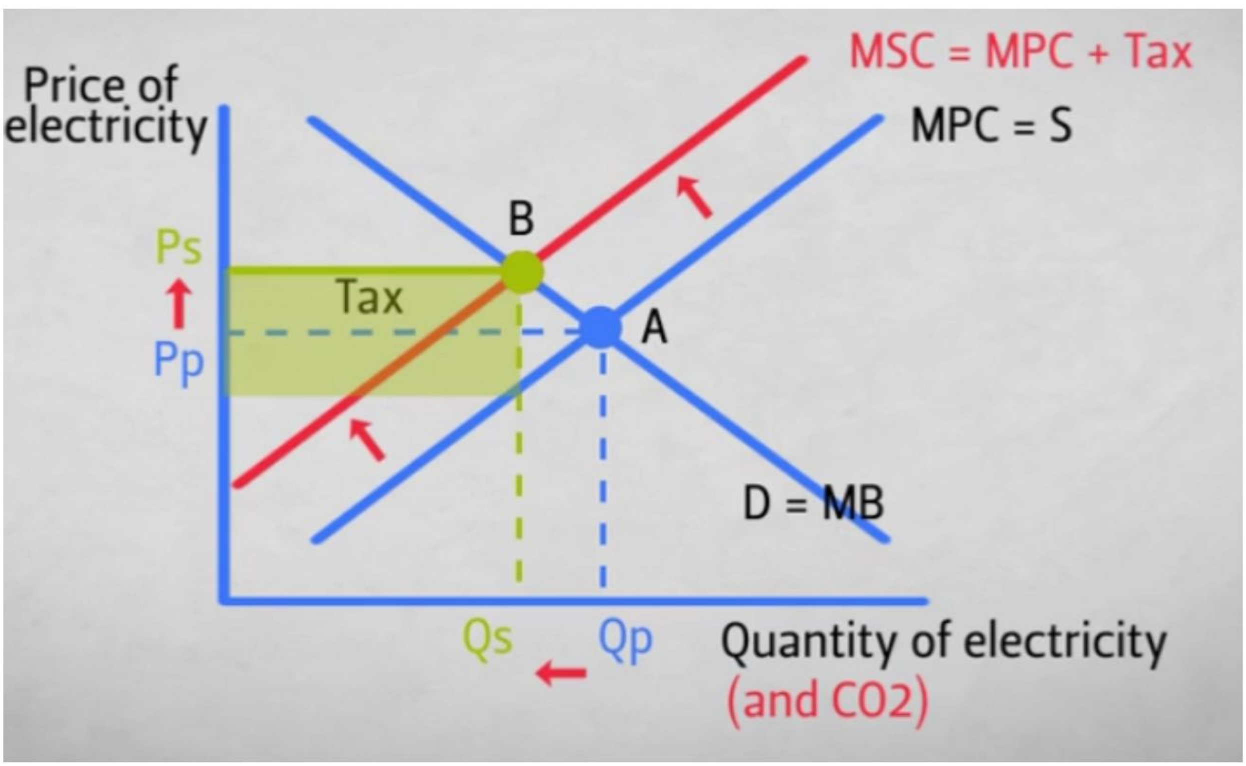
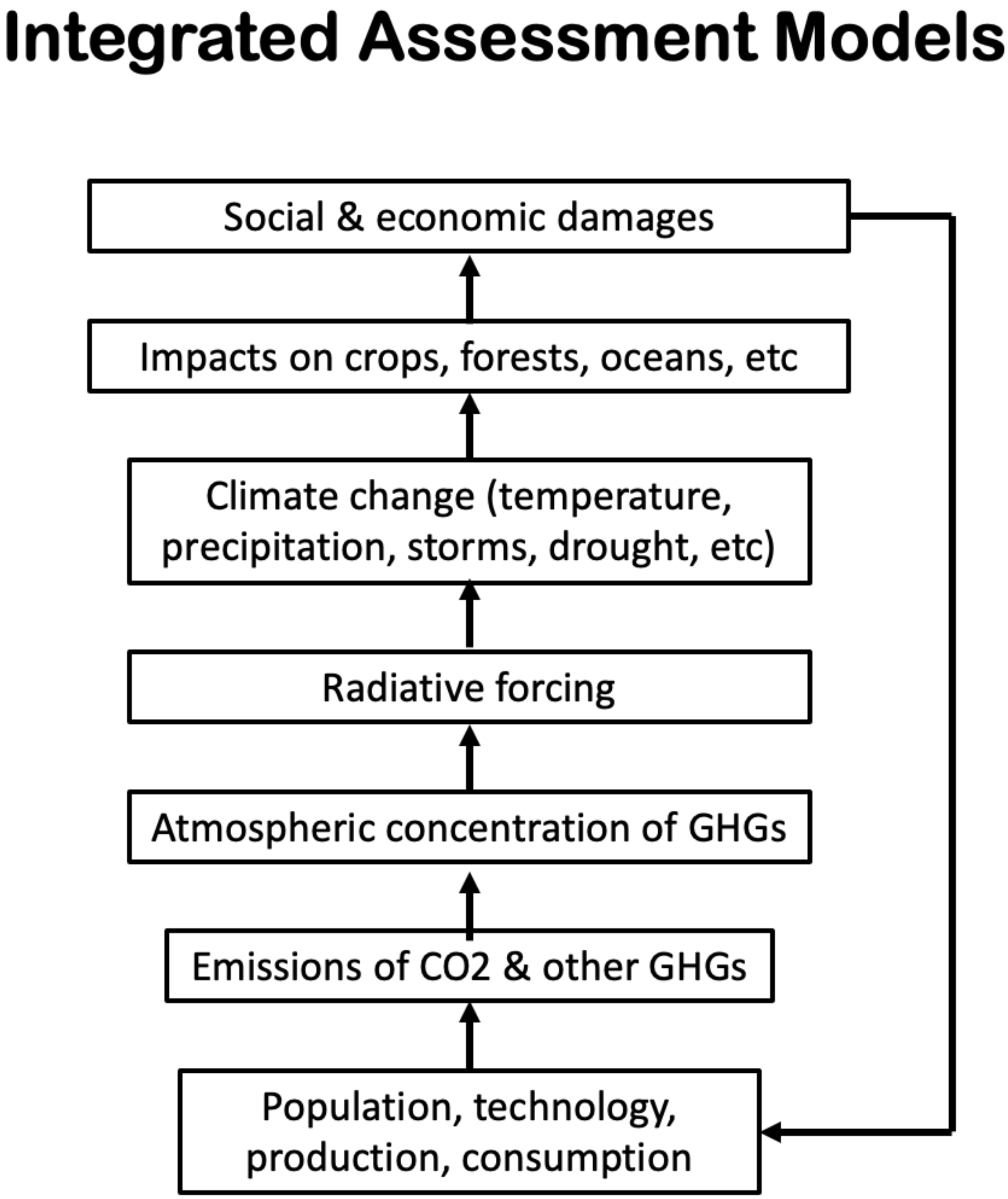


Figure 11-2: A carbon tax can shift the balance of energy supply and demand to internalize the social cost of carbon by increasing energy prices. This changes the supply/demand equilibrium from point A (with a private price Pp and quantity Qp) to pint B (with social price Ps and social quantity Qs). Schmittner (2019). Creative Commons.

11.5.1 Integrated Assessment Models (IAMs)

Calculation of the social cost of carbon (SCC) is done with Integrated Assessment Models (IAMs). These models attempt to connect all the causal links between economic production, fossil fuel combustion, CO_2 emissions, changes in climate, economic damages of climate change, and the consequent changes to economic growth and policy. IAMs include a lot of logic beyond what an Earth System Model does, and in practice they typically reduce the Earth system to a few very simple equations without spatial resolution.



Internalizing the SCC by adding a carbon price to energy is intended to allow efficient markets to optimally adjust prices and quantities across the economy to reduce CO_2 emissions. According to free market theory, these adjustments made by producers and consumers responding to price and profit incentives should "automatically" lead to the most efficient and least expensive balance of contemporary investments and avoid catastrophic climate change.

Prof. William Nordhaus

One of the most famous IAMs is called DICE (Dynamic Integrated Model of Climate and the Economy). It was developed by economist William Nordhaus over a long career for which he was awarded the Nobel Prize in Economics in 2018.

As DICE is run forward over many years and decades, it calculates the SCC (in dollars per ton of CO_2 emissions) which gets added to fuel prices to account for future damages to the economy due to climate change. The calculated SCC rises gradually to make fossil fuels more and more expensive and thereby shift investment toward energy efficiency and clean energy. Nordhaus has used DICE to explore the impact of various assumptions on the calculated SCC. By far the most consequential assumption in his calculations is the discount rate he uses to balance the present value of future damages against the costs of cleaning up the global energy supply (see previous section).

DICE Social Cost of Carbon Under Various Assumptions

After Nordhaus (2017), Proceedings National Academy Science

Assumption	SCC 2030 ($/ton)	SCC 2050 ($/ton)
Discount rate = 5%	29.1	49.2
Discount rate = 4%	51.1	81.7
Discount rate = 3%	104.9	156.6
Discount rate = 2.5%	164.6	235.7
Stern Review discounting	376.2	629.2
Limit global warming to 2.5 ℃	351.0	1006.2

11.5.2 Effect of Discount Rates on the Social Cost of Carbon

Depending on the assumed preference for spending money now or later (that is, the discount rate), DICE calculates an optimal carbon price in 2050 that varies by more than aa factor of 20 (from $49/ton to $1006/ton)! When Nordhaus used the discounting preferences recommended by his rival economist Nicholas Stern the carbon price goes up by more than a factor of 10 compared to his own "best" assumptions.

When he forces DICE to limit warming to 2.5 °C the carbon price in DICE skyrockets to over $1000/ton. Recall that the nations of the world have already committed to limit warming to 2.0 °C (and 1.5 °C if possible) in the Paris Agreement of 2015. In his 2017 paper that's Nordhaus doesn't even consider using DICE to calculate the required carbon tax to hit the Paris targets. Presumably it would be much higher than the $1006/ton required to miss the Paris targets by a wide margin!

There are many adjustable parameters in DICE and other IAMS, but the assumed discount rate produces by far the biggest spread in the calculated SCC. Natural scientists are stung by the fact that Earth system models and paleoclimate data yield estimates of global warming per doubling of CO_2 that are uncertain by less than a factor of two (2.5 °C to 4.0 °C per doubling of CO_2). But the uncertainty in the recommendations of Integrated Assessment Models (even by one economist using just one such model) are uncertain by a factor of more than 20!

11.5.3 No Global Taxing Authority

Policymakers trying to use IAMs to set a carbon price must set the SCC somewhere between $49/ton and $1006/ton. But *there is no such thing as a global taxing authority*. There is no real-world scenario in which a government can set a price on carbon that can redirect resources and investment across the global economy to prevent climate catastrophe. It's easy to imagine that the European Union (for example) might impose a tax of $1000/ton of emissions and that both the post-Brexit United Kingdom and the United States would choose the far lower value of $49/ton. It would become far more expensive to manufacture carbon-intensive goods in the EU, but firms might then just offshore their manufacturing to the UK and US. Emissions would barely be impacted but there would be profound economic dislocation as markets tried to adjust to wildly disparate international energy prices.

To avoid the unintended consequences of a crazy patchwork of carbon prices that result from disparate assumptions about the discount rate on climate damage, economists like Nordhaus recommend that *countries band together in "carbon clubs."* These coalitions would use international diplomacy to agree on a carbon price and impose economic sanctions through the global trade framework to punish countries that attempt to undercut the consensus carbon price.

11.6 Critiques of Climate Economics

Many serious critiques have been made of traditional climate economics. The following arguments are largely drawn from "A Rant About Economist Pundits" by the writer Dave Roberts @volts.wtf.

11.6.1 Damages Badly Underestimated

Most analyses of climate damages by economists seem ridiculously low given the fact that natural scientists are unanimous in warning of severe consequences of global warming beyond 2 ºC.

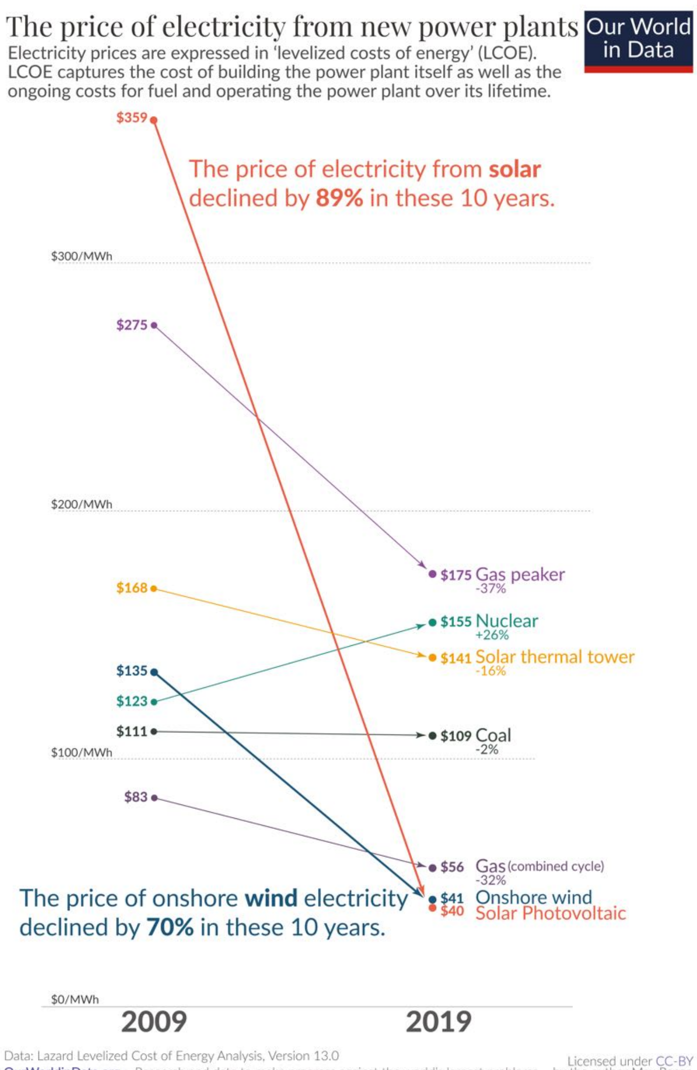
The fundamental mismatch between the costs and benefits of avoiding catastrophic damages as estimated by IAMs results from an ***assumption that exponential increases in global income***

will grow society's ability to respond to impacts faster than the damages can accrue. The quadratic scaling of damages with temperature used in nearly all IAMs are easily outstripped by the exponential growth of income assumed to occur in perpetuity.

Mathew Hampshire-Waugh (https://net-zero.blog) considers economic damages from respiratory illness, loss of coastal land, huge numbers of refugees, productivity loss, and famine as compounding problems. His analysis suggests that climate damages will sap future economic growth so that ***damages actually rise faster than income***. In this case unmitigated climate could reverse centuries of rising human prosperity that began with the industrial revolution.

11.6.2 Technologically Naïve

Economists assume that clean energy is extremely expensive.



They treat changing technology as something external that just happens naturally and apply it in their models at a set rate. The real world of energy costs bears no resemblance to that of a decade ago. The costs of clean energy have fallen by 80% to 90% since 2010, with solar and wind power now by far the cheapest sources of electricity. Nearly all new electricity deployed in the past few years has been cheap solar and wind.

In older IAMs, coal-fired power plants just keep operating as part of a baseline economy that grows exponentially and new solar and wind generation are considered costly mitigation. In the real world, coal-fired power plants are being decommissioned because it's cheaper to build brand-new solar and wind generation than it is to simply operate creaky old coal plants that are already bought and paid for. More people in the US work at the Arby's restaurant chain than work in the entire coal industry!

Economists rationalize this naivete by defining it away. When governments and businesses make investments in clean energy that are sensible and profitable in the here-and-now, they don't count as "costs" in the traditional cost-benefit analysis of climate policy. IAMs only consider costs of CO_2 emissions abatement that are unprofitable, so they remain stuck in the energy marketplace of 2007 when coal was cheaper than wind and solar.

There's an old joke about economists' trust in efficient markets that is richly applicable here.

Two economists are walking down the street when they spot a $20 bill lying on the sidewalk. One stoops to pick it up but the other stops him.

"Don't bother," she says. "If it were real, somebody would already have picked it up."

11.6.3 Intergenerational Discounting

The arithmetic similarity of the function of compound interest and economic discounting makes it tempting to simply use interest rates set by credit markets as estimates of people's perceptions and values about the future. In fact, Nordhaus and many other conventional climate change economists derive estimates of discount rates for climate damages from market interest rates.

But the potential *economic damage arising from climate change stretch out into the distant future in a way that dwarfs the timescales of money market accounts* or US Treasury Bonds. As we saw in Module 9, much of the CO_2 we emit in the 21st Century will still be warming Earth's climate thousands of years from now. Today's global population is about 8 billion people, but over the coming millennia trillions of people will suffer the economic damage of today's CO_2 emissions.

When economists use interest rates on 10-year or 30-year investments to estimate the present value of future climate damage, tohey are essentially claiming that short-term gains of a measly few billion people outweigh the economic harm to trillions of people that haven't yet been born. This is an incredibly aggressive claim of economic privilege that fails to account for the actual preferences of today's parents and grandparents, let alone future generations.

11.6.4 Existential Risk

Nearly all economic analyses of climate change treat exponential economic growth as a fundamental fact and fail to properly account for the risk of total global catastrophe. This feature of economic theory is at odds with the results of natural science which show damages escalating with every bit of fossil fuel ever burned.

Russian Nagant revolver. Mascamon at Luxembourgish Wikipedia CC-BY 3.0

The risk of total economic and social collapse due to continued combustion of fossil fuel may be very small but it is certainly not zero. *Low-probability outcomes with catastrophic consequences* (so-called "tail risks") are well-known to statisticians and insurance markets. The odds of a particular home burning to the ground in a given year are infinitesimal. Yet all homeowners with mortgages are required to carry fire insurance to protect the bank in the extremely unlikely event that the home is destroyed and the financial asset becomes worthless.

It still seems likely to me that people will realize that the harms from burning carbon far outweigh the benefits, and that we will act in time to prevent social and economic collapse. But it is precisely the existential risk of failure that motivates prevention. It is imperative that cost-benefit analysis of climate policy weigh modest investment now to prevent the destruction of modern society.

11.6.5 Marginal Analysis of a Transformational Problem

Recall that economic theory weighs decisions based on costs and benefits at the margin rather than integrated over the entire future market. This is sensible for making small adjustments to a system that is fundamentally stable and is simply being nudged by local incentives.

But the climate problem threatens the stability of the entire economy and natural world in which it's embedded, and solving it requires transformation of the way energy is generated, distributed, and used among hundreds of countries at all levels of development.

It is *inappropriate to assess the costs and benefits of such wholesale sociotechnological change using utility functions (measures of overall "goodness" or "size of the pie") that are designed to model small changes at the margins* of existing systems.

11.6.6 Efficiency vs Ethics

The economic obsession over optimally efficient policy ignores other values and trade-offs that are always important in social and political decisions. In the real world, major political decisions are not made using technical calculations of optimal costs and benefits – though this may be seen as unfortunate by economists!

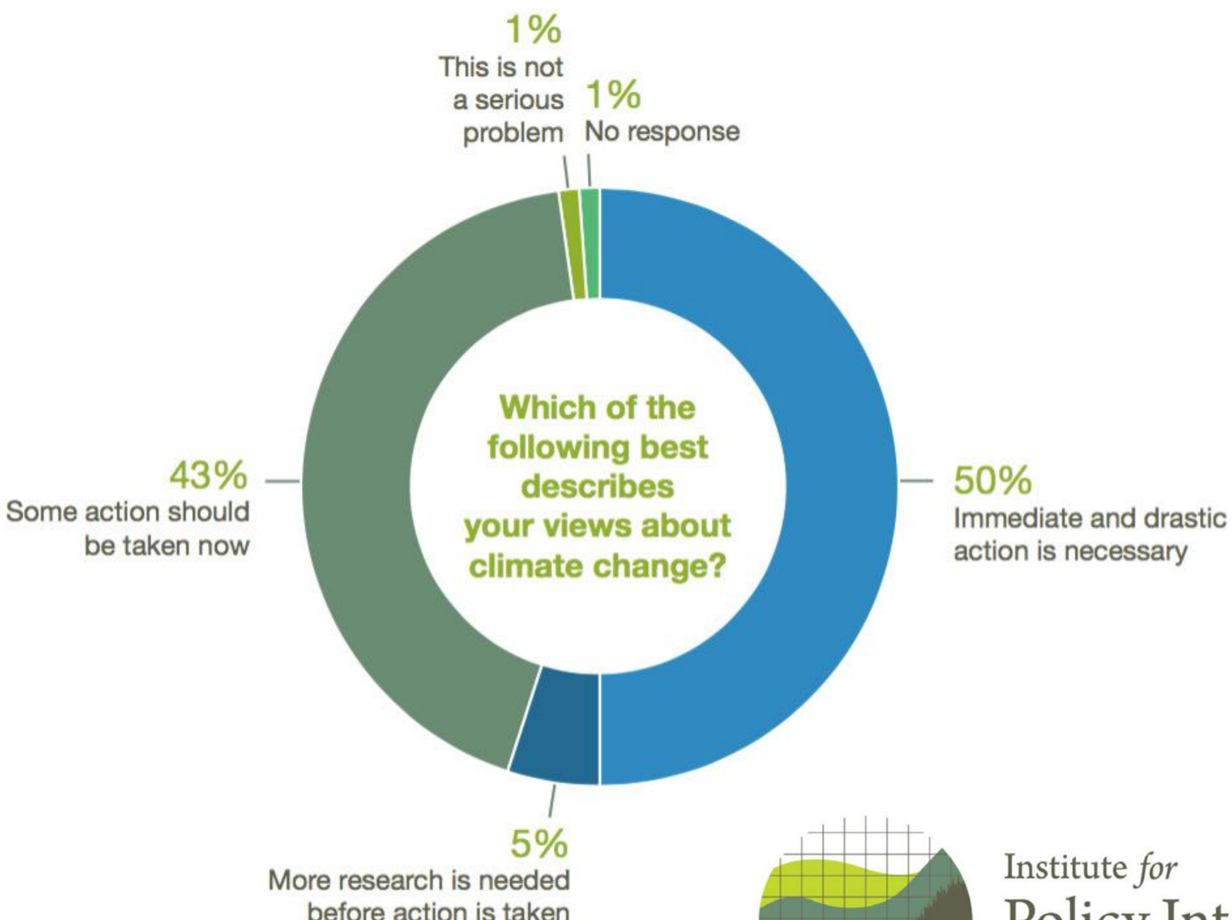
Historically, policy response to major threats is not dictated by economic theory but rather by a broad consideration of values and ethics. In matters of war and peace, diplomacy, and even diplomatic policy, free societies make value judgements that transcend purely economic calculations.

Climate change economics offers radical value judgements disguised as rational calculations. "Discounting future damages" is just a fancy way of saying "we don't care about you" to our children and grandchildren and future generations who have no say in the matter. It is not a trivial matter to know the actual social and political preferences of contemporary people about causing intentional harm to their descendants, but it is dishonest not to ask us.

11.7 Do Something!

It's important to close out this module by noting that *the vast majority of practicing economists support strong policy to prevent climate catastrophe*.

The Institute for Policy Integrity at New York University's School of Law surveyed academic economists who publish on climate change in top economics journals about their policy preferences. They received responses from 365 scholars. Nearly all of them prioritize climate solutions over inaction, and only 5% suggested that "more research is needed." Only 1% felt that climate change is not a serious problem.



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